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The BaBar Calorimeter Light Pulser System

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Abstract

To make precision measurements with a CsI(Tl) calorimeter in a high luminosity environment requires that the crystals are well calibrated and continually monitored for radiation damage. This should not effect the total integrated luminosity which is particularly important for the *BaBar* calorimeter to enable it to make *CP* violation measurements in the *B* meson system. To achieve this goal a fibre-optic light pulser system was designed using xenon flash lamps as the light source. A novel light distribution method was developed using an array of graded index microlenses. Some initial results from performance studies are presented.

[1)] On behalf of the *BABAR* collaboration.

1 Introduction

The light pulser system monitors short term changes in the response of the BaBar calorimeter [1]. It also provides a useful and flexible diagnostic tool for the entire readout chain of the calorimeter from light collection through to data acquisition. The system is designed to have a stability of 0.5% over a period of around one week. It can also monitor long term changes in the calorimeter response to an accuracy of 1% using a reference system which cross-calibrates the intensity of the light pulses against a radioactive source.

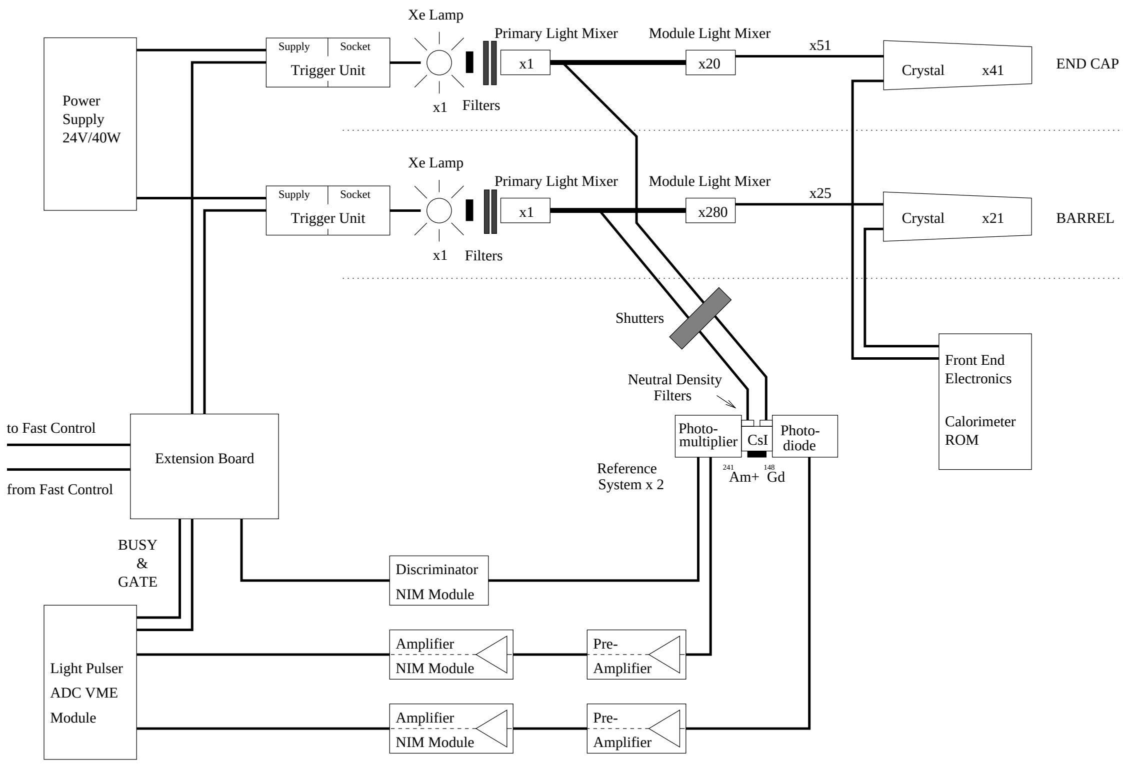

Figure 1: Overview of the light pulser system

The overall design of the light pulser system is shown in figure 1. There are two high stability xenon flash lamps manufactured by Hamamatsu (type L4633). One of the lamps supplies the barrel and the other supplies the endcap calorimeter. The light produced from the xenon lamps is spectrally filtered to match the emission spectrum of CsI scintillation light. It is then attenuated by two neutral density filters to allow the correct equivalent energy in the calorimeter crystals to be selected. The light fills a light mixer bar which uniformly illuminates a bundle of 400 μm multi-mode fibres which deliver the light to the individual calorimeter modules. At each module there is a module mixer which takes the light from each fibre and illuminates a close-packed bundle of 200 μm fibres which transport light to individual CsI crystals. The light is injected into the rear face of each crystal and then diffusely reflects within the crystal. This effectively imitates the crystal scintillation light produced by the energy deposition of an electromagnetic shower. The light is then readout using the full BaBar calorimeter electronic readout chain from the photodiodes right through to the data acquistion. The light pulser system produces an equivalent energy in the calorimeter which is high enough to allow it to be run with beam backgrounds in the detector. A more detailed description is given elsewhere [2].

There is a reference system to take out instabilities in the light source. Fibres are routed from the primary mixer systems to the reference system. The reference system itself is cross-calibrated against a mixed alpha source (^{148}Gd and ^{241}Am). Both the alpha source and the reference fibres are attached to a small CsI crystal which is readout by a photomultiplier tube and a photodiode. The reference system data from both source events and light pulses is collected in the multi-event buffer of a 12 bit peak sensing ADC (CAEN V556S). The source events are accumulated continuously in the buffer and readout using a 1 Hz software trigger. The readout of light pulser system events is triggered from a signal which is derived from the photomultiplier tube in the reference system. This is more accurate than using the input signal to the lamp trigger power supply because there is a time jitter of 200 ns in the lamp response with respect to the trigger. The lamps are triggered at a frequency of 14.2 Hz which comes from dividing the BaBar clock.

2 Graded index microlenses

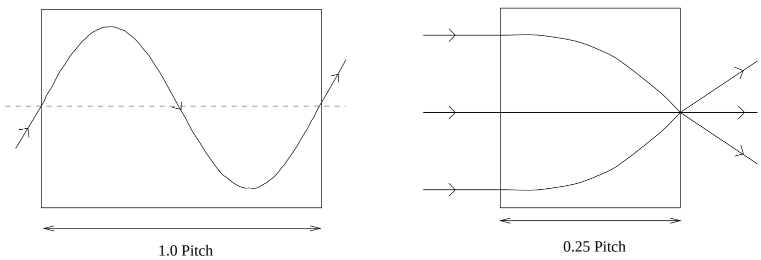

Figure 2: The principle of the microlens

In the endcap system graded index microlenses (Newport LGI630-3) are used to ensure that all the light modes in the 400 μm fibres are filled correctly. This led to a better uniformity in the energy distribution. Conventional fibre optics rely upon having a step refractive index where the fibre core is at a higher refractive index than the cladding. Graded index fibre optics however do not have a separate core and cladding. Instead they have a refractive index that varies radially. This results in an optical ray following a sinusoidal path down the fibre rather than discrete total internal reflections, see figure 2. An interesting feature of these fibres is if they are cut at specific lengths they act as minature lenses. If an optical ray completes one sinusoidal oscillation within the lens it is said to have a pitch of 1.0. For our case lenses with a pitch of 0.25 allow a collimated light source to be focused. This is ideal for input into a fibre optic. Each lens is coated in an anti-reflection coating (MgF_2) to maximise its transmission. The type of lens which was chosen was plano-plano meaning that the lens is terminated perpendicularly at both ends.

3 Stability of the system

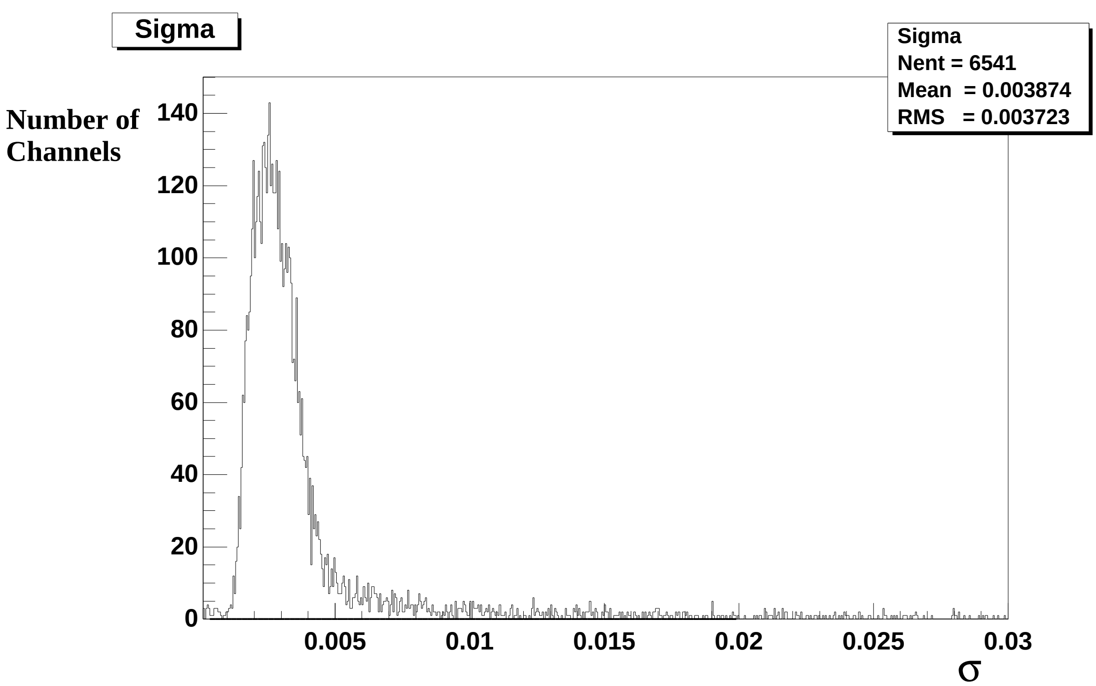

Figure 3: The stability of the light pulser system

It is important for the light pulser system to have as high a pulse-to-pulse stability as possible. In figure 3 the stability of the system is shown. This is produced by a Gauss fit to the energy distribution in each channel. The data is normalised to the mean energy in each calorimeter module on a pulse-to-pulse basis. There are a small number of noisy channels due to preliminary electronics problems.

4 Summary

Using the light pulser data from the inner ring of crystals in the endcap calorimeter, where maximum radiation damage occurs, it is possible to obtain a correlation between the total integrated luminosity of data taken by BaBar and the differential radiation damage in the endcap. This is the radiation damage to the inner ring with respect to the rest of the endcap. The correlation is shown in figure 4. This demonstrates that the light pulser system can measure accurately very small changes in the response of the BaBar calorimeter.

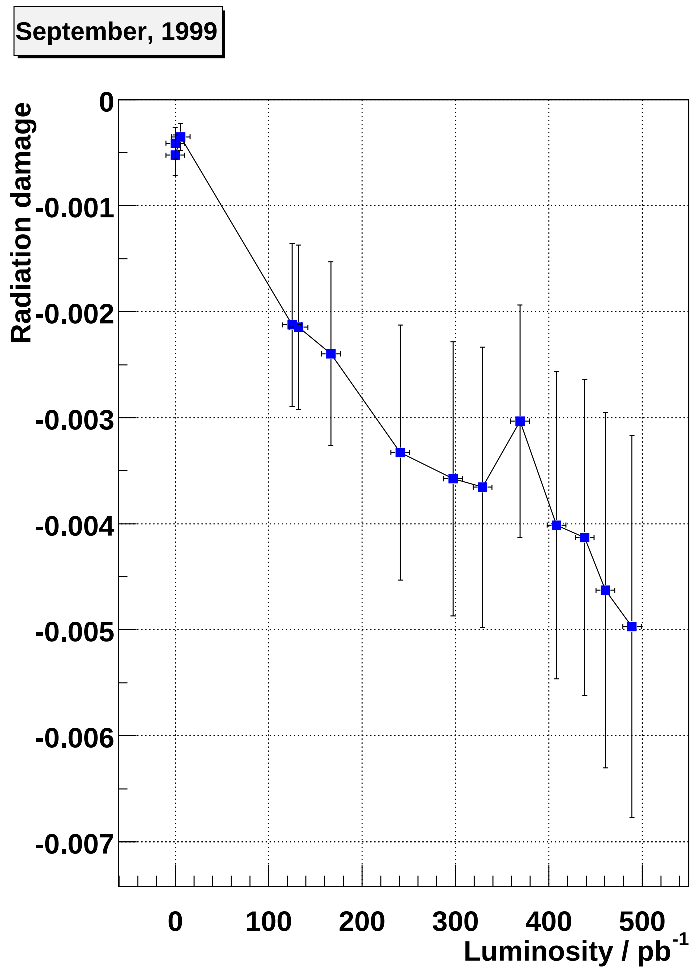

Figure 4: Differential radiation damage in the endcap versus total integrated luminosity

References

[1] D. Boutigny et al. Babar technical design report. 1995. SLAC-R-0457.

[2] P.J. Clark. *The BaBar Light Pulser System.* PhD thesis, University of Edinburgh, 2000.